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Spot Robot Staffing Augmentation in Process Modeling and Analysis (E-2)

Engineering Leadership Council Seminar
May 1, 2023

Presenter
Jeffrey Hyde, E-2

Background

- In September 2021 E-2 obtained its first Spot robot from Boston Dynamics to evaluate their suitability for work in and around laboratory facilities.
- Spot is a highly mobile quadruped robot capable of up to 90 minutes of operation. They can be outfitted with payloads up to 30 pounds and support Boston Dynamics-developed equipment, third party payloads, or custom-developed payloads.
- The platform showed immediate promise resulting in the procurement of a total of four units by the end of FY22 (Trinity, Gadget, Crossroads, and Sandstone).

Inspecting the C-130 at TA-49

Trinity and Gadget

Initial Radiation Testing

- Many early notional use cases included performing work within radiation areas but there was limited data on Spot's radiation tolerance.
- Two vendor-supplied Spot robots were tested for a week at TA-49 to verify their ability to operate in a high radiation environment using Co-60 sources (4 and 12 Currie).
- Key findings include:
  - Both robots successfully operated autonomously in a +100 REM/hour field.
  - No failures were observed with a maximum total dose of 413 REM.
  - Gamma radiation induced "Snow" was observed on the robots' cameras but had no impact on autonomous operation.

High radiation testing at TA-49

Radiation Testing Video

Video From Onboard Camera

Inspection Photographs from Testing

Figure 4: Inspection photographs obtained by the Spot robots throughout testing

- Inspection photos were obtained using the existing manufacturer provided “Autowalk” functionality.
- Successive photos taken throughout the day demonstrate the robots’ ability to correctly localize within a high radiation environment using only cameras.

Pivoting to Spot Robots

- It became evident that Spot was well suited to perform a variety of tasks at the laboratory due to its:
  - Excellent integral obstacle avoidance capabilities
  - Ease to program for, due to an extensive Software Development Kit
  - Leg-based locomotion which is highly capable in a wide variety of terrain including climbing stairs and navigating facility obstacles
  - Reduced likelihood of spreading radioactive contamination
  - Ability to integrate custom payloads that utilize current sensors
- In early FY22 an existing robotics project was absorbed and pivoted to using Spot robots in place of legacy wheeled systems that were being developed to perform radiological surveys.
- By the end of FY22 E-2 completed proof-of-concept testing that demonstrated Spot's ability to execute work at the laboratory, primarily through a protype truck bed contamination survey.

Spot robot "Crossroads" training for high hazard waste movements

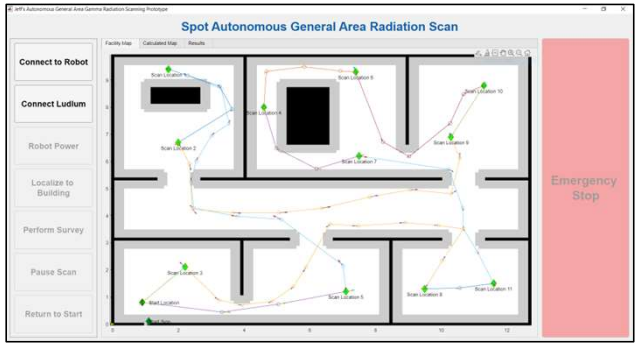
Staffing Augmentation

- Spot is intended to augment staff responsibilities that are:
  - Dangerous
  - Tedious
  - Require high precision
- Due to the high demand for Radiological Controls Technicians (RCTs) and the nature of much of their work, early Spot use cases primarily consist of augmenting long duration simple radiation surveys. This is expected to free up RCT resources to better directly support core laboratory missions.
- Surveying trucks for radioactive contamination was selected as the first full scale application as it takes place outside of facilities and is considered an undesirable task by RCTs as it is highly tedious, exposes them to the elements, and has ergonomic concerns.

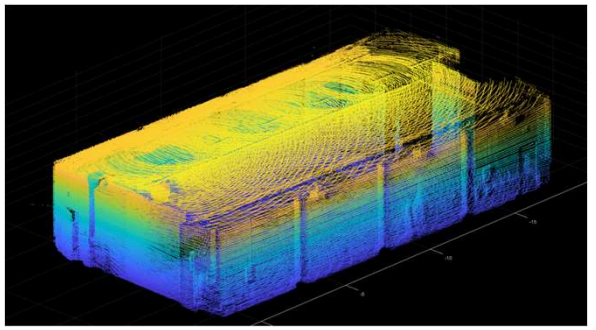
Gadget performing a truck bed scan using an early protype payload and mock detector

Additional FY23 Spot Projects

- Additional prototype capabilities are being developed to determine their suitability for full implementation including:
  - **Facility gamma radiation general area survey** - A proof-of-concept capability is being created to demonstrate the system's ability to traverse a facility to predetermined survey points. It can also add additional survey locations based on results.
  - **Object gamma radiation object survey** - A prototype capability is being developed to support LANSCE potentially activated metals release. This work is currently performed outdoors by RCTs and is also highly tedious as it requires scanning 100% of large object surfaces at approximately 2 inches per second.
  - **Facility inspection –** A prototype process that captures LiDAR surveys and photo spheres is in development. This capability is already present at the lab but is staff driven using tripod or backpack-based systems. Using Spot will help to automate the workflow to reduce staffing needs and increase scanning frequency to better support active construction projects.



Facility radiation mapping GUI


Facility LiDAR Scan Results

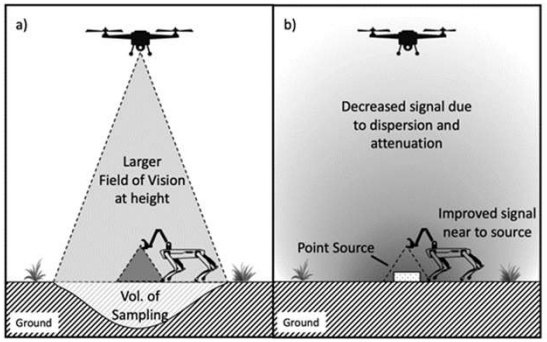
Initially Planed FY24 Work

- For FY24 the project initially expects to create full scale implementations for this year's prototype functionalities with some additional capabilities added.
  - General area gamma radiation surveys with the added capability of neutron radiation surveys. This functionality reuses nearly all the work being performed for gamma radiation surveys but would require additional hardware integration to get the larger detectors required onto the platform.
  - Object gamma radiation surveys, potentially adding alpha/betta radiation detection capabilities.
  - Facility inspections using LiDAR and photography but potentially adding additional inspection tools including thermal and acoustic sensors.
- The team is also planning to develop a facility floor contamination survey capability, building on this year's truck survey capability. This is expected help to identify locations of contamination early, hopefully prior to it being spread by foot traffic. An additional stretch goal for this work would be to develop a decontamination capability.

Other Potential Projects

- Spot demonstrations have been provided to numerous organizations internal and external to the lab. These have resulted in potential future projects and Spot implementations.
  - Emergency Response support for low oxygen alarms, suspected gas leaks, criticality accidents, and energetic material.
  - Los Alamos Fire Department implementations for search and rescue along with wildfire crew support.
  - Physical Security for personal detection and monitoring.
- A funding proposal has also been submitted in conjunction with Earth and Environmental Sciences (EES) to develop a prototype system capable of searching large areas for radioactive material/contamination. This would consist of using drone(s) to perform large area coarse surveys to identify locations of concern for a Spot robot to further investigate with detailed surveys.

Spot robot "Gadget" opening the door during a training exercise



Spot robot working with drones to find, identify, and potentially sample areas of concern.

Other E-2 Automation/Augmentation Work

- Shipments of sealed inserts to the lab using MD-2's will begin over the next few years and ramp up over time to accommodate multiple programs. Opening these inserts is time and radiation dose intensive due to the number of bolts (36). This project is intended to demonstrate a prototype capability to automate the opening process:
  - Reducing radiation exposure to staff
  - Reducing staffing required to open a container
  - Increasing throughput
- Perform proof of concept testing and analysis is also underway to determine the viability of a drone-based inventory system for remote high value objects at the lab. This would increase inventory cadence without the need for additional staffing or infrastructure upgrades.

UR-16 robot arm paired with an electric nut runner

Alta X heavy lift drone from Freefly

FY23 Challenges

- The robotics program lacks indoor development and testing space. Executing development work in a parking lot at TA-16 has severely delayed progress over the winter months. While Spot robots proved resilient in low temperatures and snow these conditions were not conducive to executing development work.
- Several temporary solutions have been pursued but none have come to fruition. A permanent development warehouse is planned to be constructed but the current timeframe for completion is 2-7 years due to existing projects.
- The project is currently attempting to secure indoor space using temporary mobile structures as a bridge to warehouse.

Development and demonstrations in inclement weather

Additional Partners and Community Outreach

- The team currently has a contract with University of Wisconsin – Madison and is close to awarding a contract to the Massachusetts Institute of Technology (MIT) to aid in development of future capabilities and payloads.
- The robots have also served as excellent tools for community outreach, helping to inspire local area students to pursue a career in STEM fields.
- Demonstrations have been provided at local schools and events including the Los Alamos “ScienceFest” with highly positive feedback and long lines to operate the robots.

Los Alamos Middle School demonstration

Los Alamos “ScienceFest” demonstration – Photo by John McHale/ladailypost.com